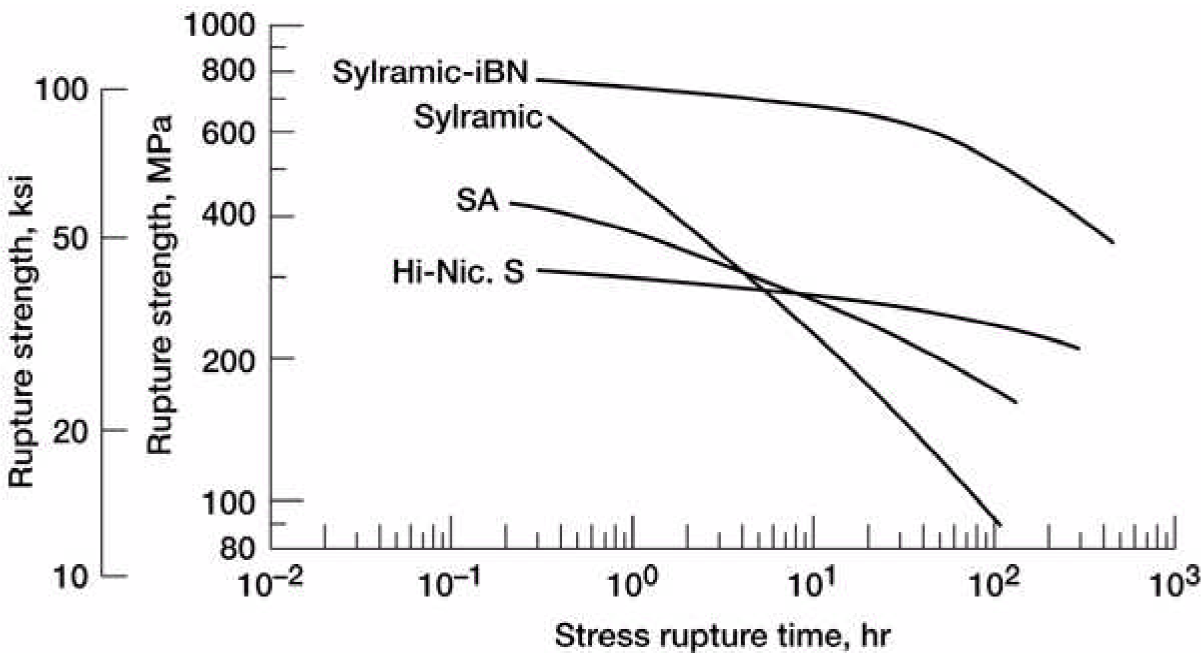
New High-Performance SiC Fiber Developed for Ceramic Composites

Sylramic-iBN fiber is a new type of small-diameter (10-μm) SiC fiber that was developed at the NASA Glenn Research Center and was recently given an R&D 100 Award for 2001. It is produced by subjecting commercially available Sylramic (Dow Corning, Midland, MI) SiC fibers, fabrics, or preforms to a specially designed high-temperature treatment in a controlled nitrogen environment for a specific time. It can be used in a variety of applications, but it currently has the greatest advantage as a reinforcement for SiC/SiC ceramic composites that are targeted for long-term structural applications at temperatures higher than the capability of metallic superalloys.

The commercial Sylramic SiC fiber, which is the precursor for the Sylramic-iBN fiber, is produced by Dow Corning, Midland, Michigan. It is derived from polymers at low temperatures and then pyrolyzed and sintered at high temperatures using boron-containing sintering aids (ref. 1). The sintering process results in very strong fibers (>3 GPa) that are dense, oxygen-free, and nearly stoichiometric. They also display an optimum grain size that is beneficial for high tensile strength, good creep resistance, and good thermal conductivity (ref. 2). The NASA-developed treatment allows the excess boron in the bulk to diffuse to the fiber surface where it reacts with nitrogen to form an in situ boron nitride (BN) coating on the fiber surface (thus the product name of Sylramic-iBN fiber). The removal of boron from the fiber bulk allows the retention of high tensile strength while significantly improving creep resistance and electrical conductivity, and probably thermal conductivity since the grains are slightly larger and the grain boundaries cleaner (ref. 2). Also, as shown in the graph, these improvements allow the fiber to display the best rupture strength at high temperatures in air for any available SiC fiber. In addition, for CMC applications under oxidizing conditions, the formation of an in situ BN surface layer creates a more environmentally durable fiber surface not only because a more oxidation-resistant BN is formed, but also because this layer provides a physical barrier between contacting fibers with oxidation-prone SiC surface layers (refs. 3 and 4).

This year, Glenn demonstrated that the in situ BN treatment can be applied simply to Sylramic fibers located within continuous multifiber tows, within woven fabric pieces, or even assembled into complex product shapes (preforms). SiC/SiC ceramic composite panels have been fabricated from Sylramic-iBN fabric and then tested at Glenn within the Ultra-Efficient Engine Technology Program. The test conditions were selected to simulate those experienced by hot-section components in advanced gas turbine engines. The results from testing at Glenn demonstrate all the benefits expected for the Sylramic-iBN fibers. That is, the composites displayed the best thermostructural performance in comparison to composites reinforced by Sylramic fibers and by all other currently available high-performance SiC fiber types (refs. 3 and 5). For these reasons, the Ultra-Efficient Engine Technology Program has selected the Sylramic-iBN fiber for ongoing efforts aimed at SiC/SiC engine component development.



Rupture strength behavior for various high-performance SiC fibers at 1400 °C in air. SA, Tyranno SA fiber from UBE Industries; Hi-Nic. S, Hi-Nicalon Type S fiber from Nippon Carbon.

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